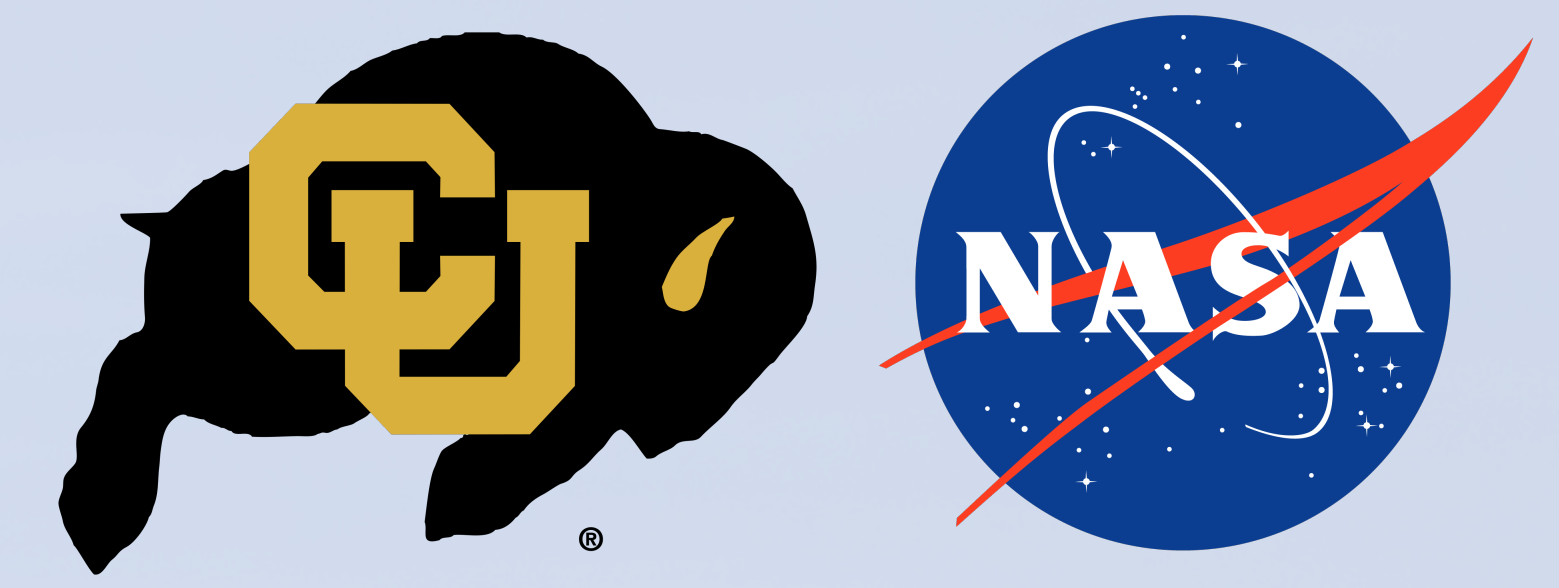




# Detecting Seasonal Changes in the Arctic Energy Budget

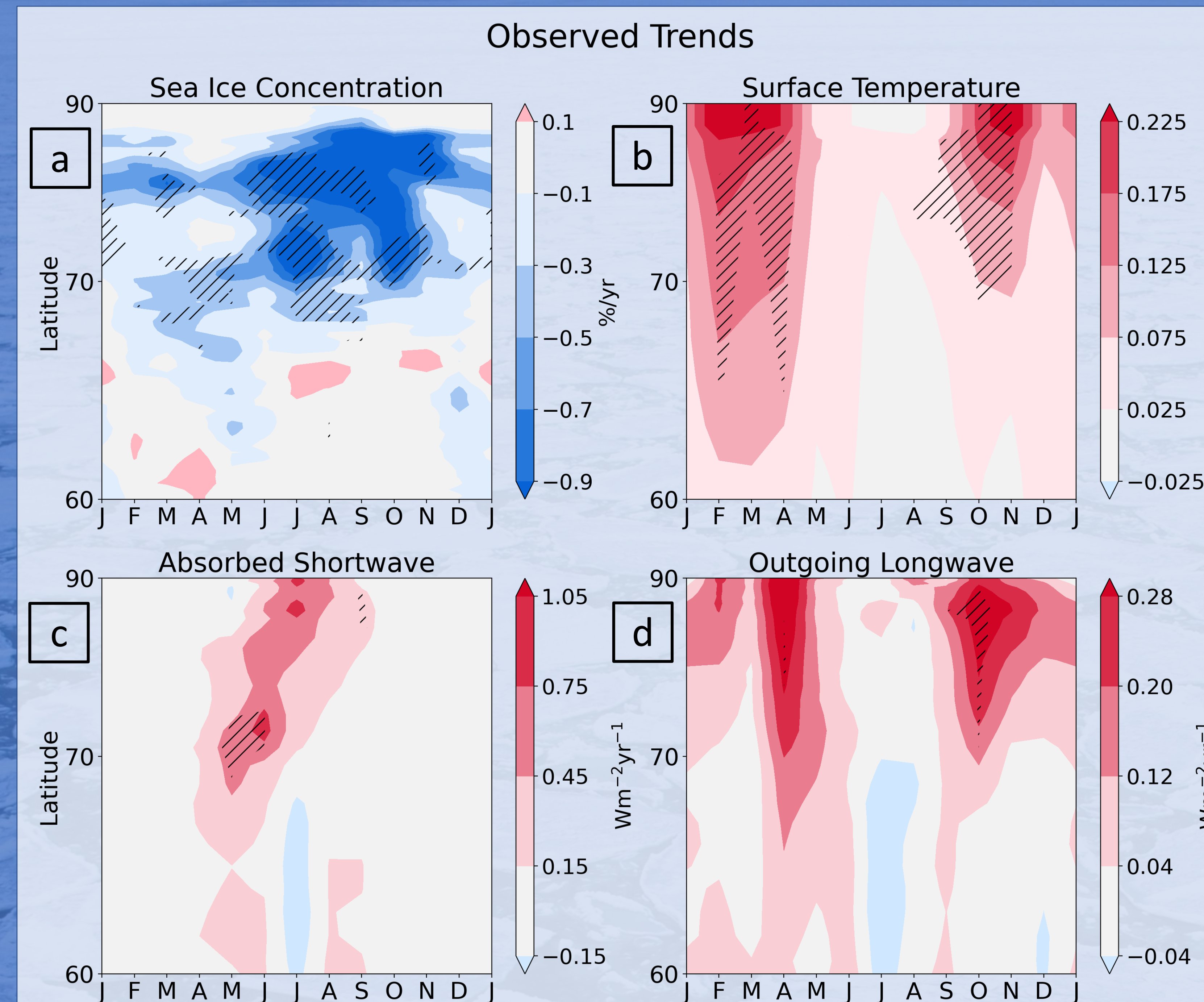
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## Motivation

- Two decades of satellite observations capture changes in short- and longwave radiation associated with sea ice loss and surface warming.
- Comparison of these observations with Global Climate Model Large Ensembles separates the forced response to anthropogenic emissions from internal climate variability.

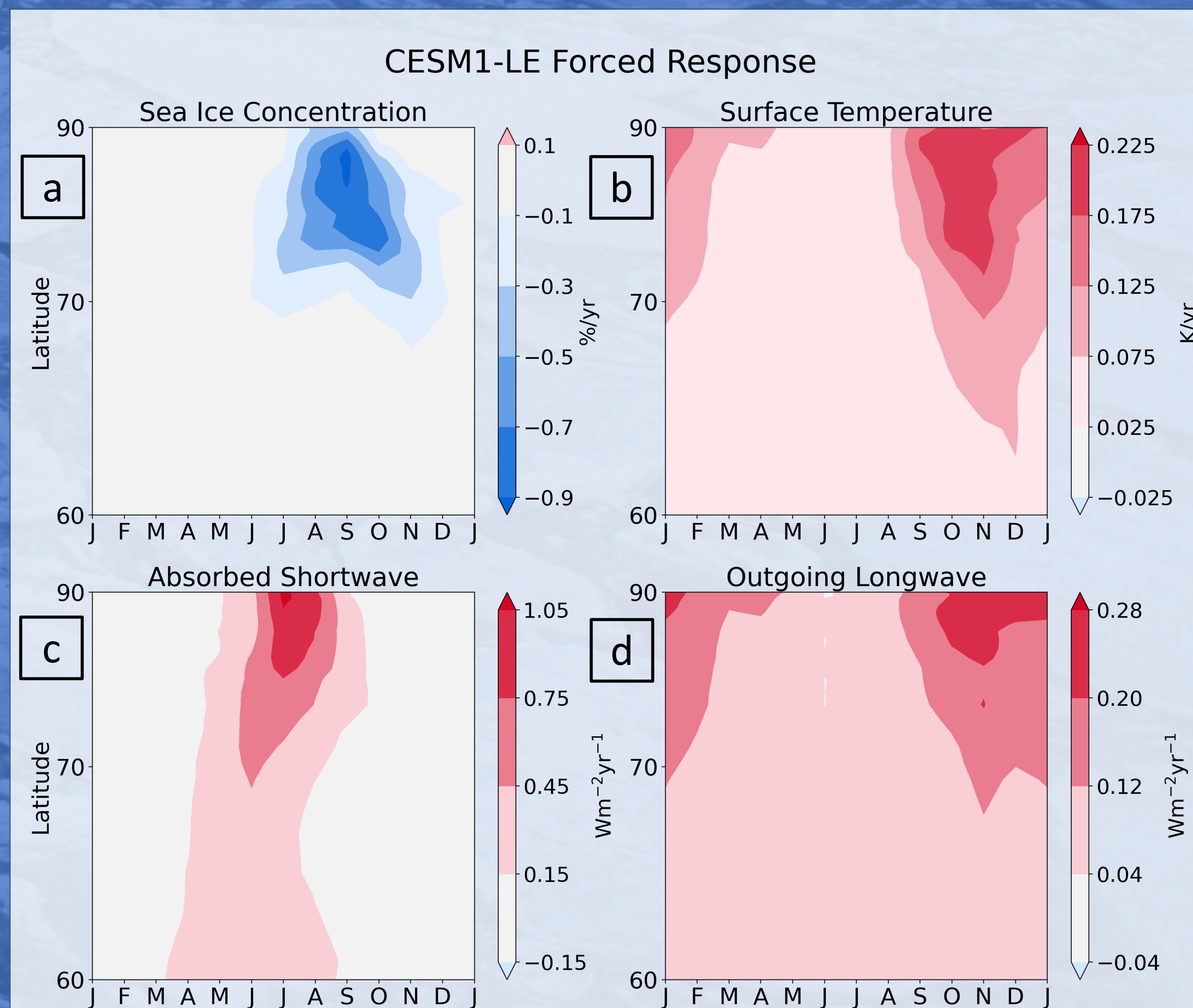
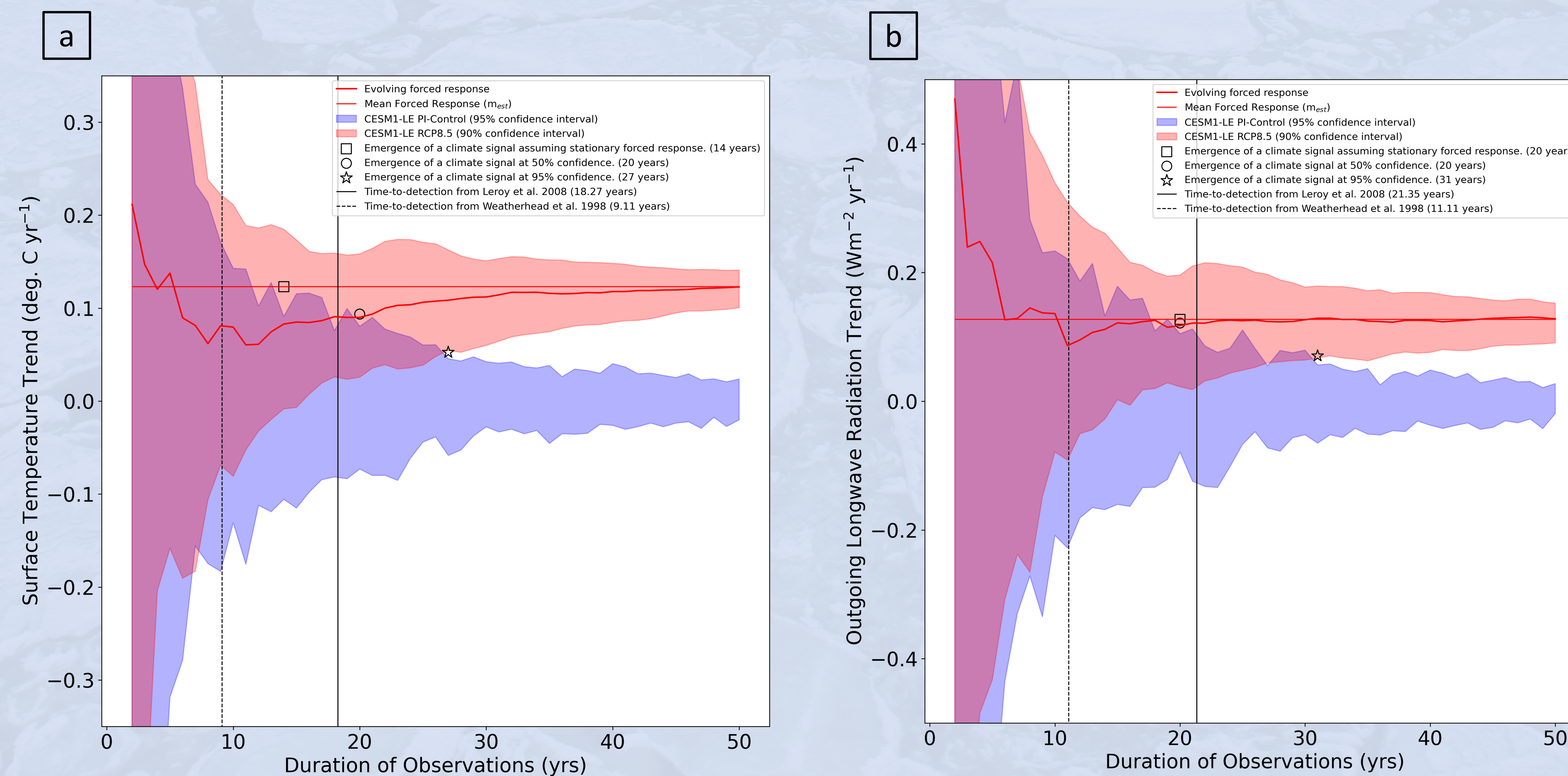


**Figure 1:** Seasonal trends in the Arctic: a) Sea ice concentration trends from NSIDC (2001-2017), b) Surface Temperature trends from GISTEMP (2001-2017), c) Observed absorbed shortwave radiation (ASR) trends from CERES (2001-2020), d) Outgoing Longwave Radiation (OLR) trends from CERES (2001-2020). Plots are stippled where observed trends exceed the 99% confidence interval.

## Key Points

- Observed trends (Fig. 1) mirror the modelled forced response (Fig. 3) across short- and longwave radiation, as well as sea ice, confirming the human fingerprint on Arctic Amplification.
- Predictions of climate signal detection must account for both non-linearities and uncertainty in the climate response to anthropogenic forcing to produce reasonable estimates for the detection of Arctic climate change (Fig. 2).

**Figure 2:** Comparing different metrics for climate signal detection and emergence using surface temperature and OLR fields from the Community Earth System Model Version 1 Large Ensemble: a) Detection of changes in the Arctic annually averaged surface temperature, and b) detection of changes in the Arctic annually averaged OLR.



**Figure 3:** Forced Response of the Community Earth System Model Version 1 Large Ensemble (CESM1-LE). a) Sea ice concentration trends, b) Surface temperature trends, c) ASR trends, d) OLR trends.

## Future Work

- Use multi-spectral observations to study vertical temperature and water vapor trends, quantify the spectral fingerprint of Arctic Change
- Investigate coupling strength between variables in the observations, individual ensemble members, and the forced response
- Investigate observed springtime trends absent from the modelled forced response: Internal variability or missing model physics/forcing?

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